Silicate Chemistry

Student Activities

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Crustal Elements

On the Periodic Table blank sheet, summarise the information in the "Elements in the Earth's Crust Table" using the following steps.

- With a black pen, write the element symbol and ionic radii in the correct square.

- Using the following colours, lightly colour the squares to show the abundance of the elements in the Earth's crust.

Red	greater than 25.0%
Yellow	less than 25.0% but greater than 1.0%
Blue	less than 1.0% but greater (or equal to) than 0.01%

Leave blank (white) all those elements which are less than 0.01%

? How many elements are red _____

? How many elements are yellow _____

? How many elements are blue _____

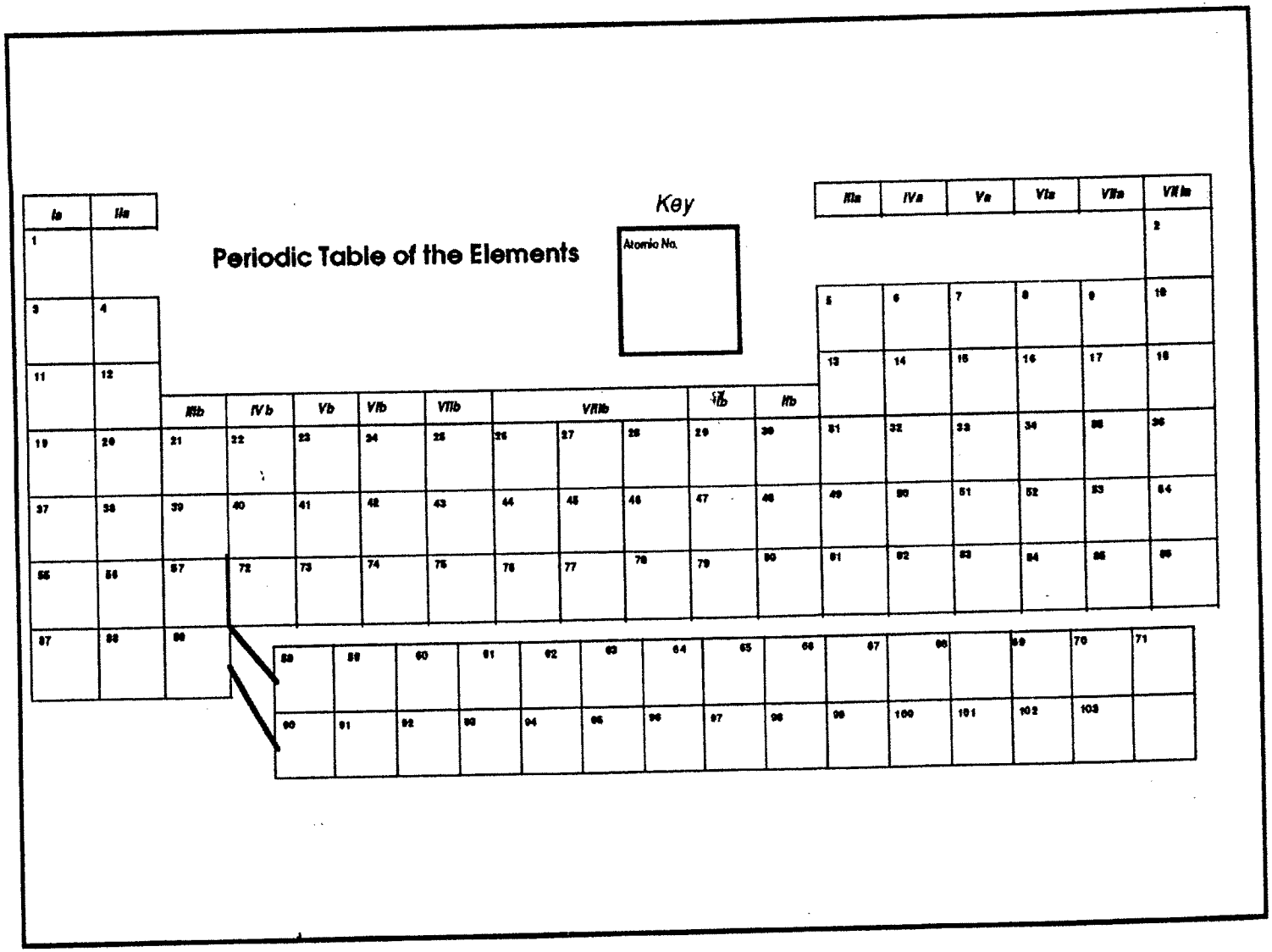
? How many elements are white _____

Elements in the Earths Crust

(Percent by weight/Ionic Radii of most common ion)

Atomic Number		g/t	%	Ionic Radii Angstrom units
1	H	1400	0.140000%	0.46
3	Li	20	0.002000%	0.68
4	Be	2.8	0.000280%	0.35
5	B	10	0.001000%	0.23
6	C	200	0.020000%	0.16
7	N	20	0.002000%	0.16
8	O	466000	46.600000%	1.40
9	F	625	0.062500%	1.33
11	Na	28300	2.830000%	0.97
12	Mg	20900	2.090000%	0.66
13	Al	81300	8.130000%	0.51
14	Si	277200	27.720000%	0.39
15	P	1050	0.105000%	0.44
16	S	260	0.026000%	1.74
17	Cl	130	0.013000%	1.81
19	K	25900	2.590000%	1.33
20	Ca	36300	3.630000%	0.99
21	Sc	22	0.002200%	0.81
22	Ti	4400	0.440000%	0.76
23	V	135	0.013500%	0.88
24	Cr	100	0.010000%	0.63
25	Mn	950	0.095000%	0.80
26	Fe	50000	5.000000%	++ 0.74 +++ 0.64
27	Co	25	0.002500%	0.72
28	Ni	75	0.007500%	0.69
29	Cu	55	0.005500%	0.96
30	Zn	70	0.007000%	0.74
31	Ga	15	0.001500%	0.62
32	Ge	1.5	0.000150%	0.73
33	As	1.8	0.000180%	0.58
34	Se	0.05	0.000005%	1.93
35	Br	2.5	0.000250%	1.96
37	Rb	90	0.009000%	1.47
38	Sr	375	0.037500%	1.12
39	Y	33	0.003300%	0.92
40	Zr	165	0.016500%	0.79
41	Nb	20	0.002000%	0.74
42	Mo	1.5	0.000150%	0.70
44	Ru	0.01	0.000001%	0.67

Atomic Number		g/t	%	Ionic Radii Angstrom units
45	Rh	0.005	0.000001%	0.68
46	Pd	0.01	0.000001%	0.80
47	Ag	0.07	0.000007%	1.26
48	Cd	0.2	0.000020%	0.97
49	In	0.1	0.000010%	0.81
50	Sn	2	0.000200%	0.93
51	Sb	0.2	0.000020%	0.76
52	Te	0.01	0.000001%	2.11
53	I	0.5	0.000050%	2.20
55	Cs	3	0.000300%	1.67
56	Ba	425	0.042500%	1.34
57	La	30	0.003000%	1.14
58	Ce	60	0.006000%	1.07
59	Pr	8.2	0.000820%	1.06
60	Nd	28	0.002800%	1.04
62	Sm	6	0.000600%	1.00
63	Eu	1.2	0.000120%	0.98
64	Gd	5.4	0.000540%	0.97
65	Tb	0.9	0.000090%	0.93
66	Dy	3	0.000300%	0.92
67	Ho	1.2	0.000120%	0.91
68	Er	2.8	0.000280%	0.89
69	Tm	0.5	0.000050%	0.87
70	Yb	3.4	0.000340%	0.86
71	Lu	0.5	0.000050%	0.85
72	Hf	3	0.000300%	0.78
73	Ta	2	0.000200%	0.68
74	W	1.5	0.000150%	0.70
75	Re	0.001	0.000000%	0.72
76	Os	0.005	0.000001%	0.69
77	Ir	0.001	0.000000%	0.68
78	Pt	0.01	0.000001%	0.80
79	Au	0.004	0.000000%	1.37
80	Hg	0.08	0.000008%	1.10
81	Tl	0.5	0.000050%	1.47
82	Pb	13	0.001300%	1.20
83	Bi	0.2	0.000020%	0.96
90	Th	7.2	0.000720%	1.02
92	U	1.8	0.000180%	0.97


Periodic Table of the Elements
Key
Atomic No.
Ia
IIa
IIIb
IVb
Vb
VIb
VIIb
VIIIb
Ib
IIb
IIIa
IVa
Va
VIa
VIIa
VIIIa
1
2
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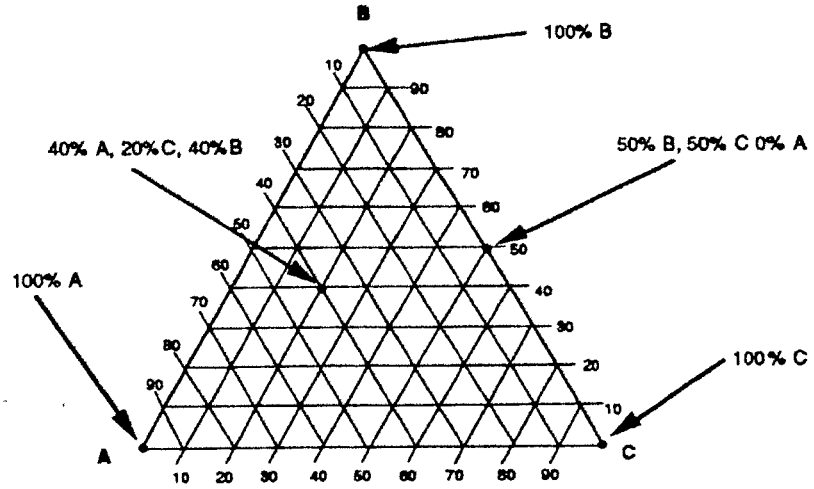
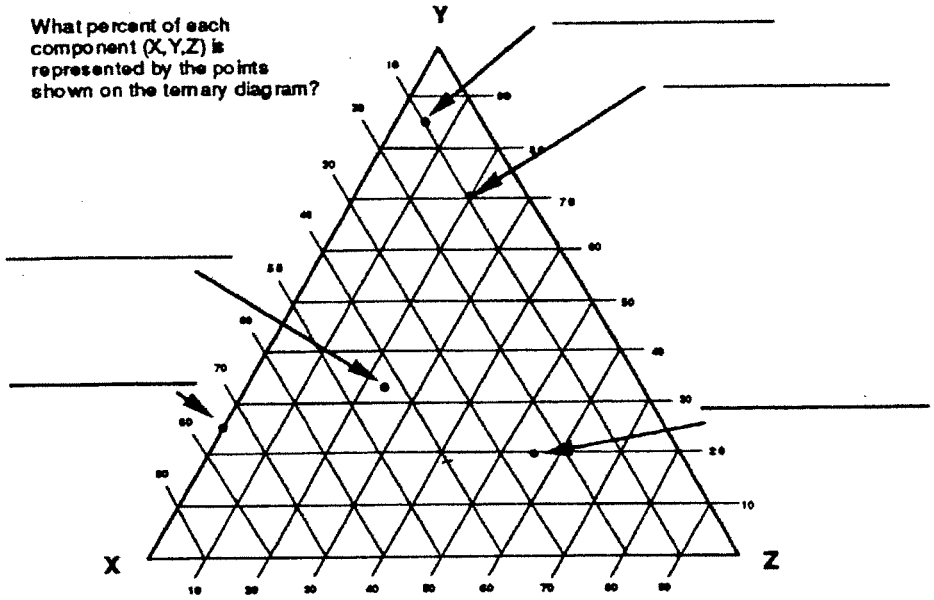
Reading Ternary Diagrams



What percent of each component (X,Y,Z) is represented by the points shown on the ternary diagram?



Plot the following points

12%X, 66%Y, 22% Z

33%X, 33%Y, 33%Z

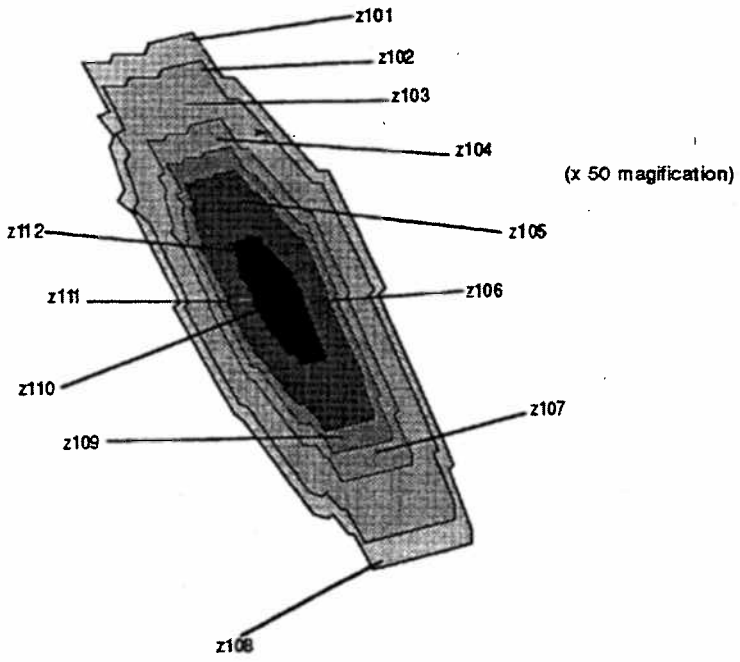
28%X, 24%Y, 48%Z

Chemical Zones

A geologist collected a sample of a rock containing the mineral feldspar (a tectosilicate) and noticed that the feldspars were zoned. Zonation occurs when a mineral crystallises from a solution, in this case molten rock, which changes composition over time.

The geologist gave a piece of the rock to a geochemist who used an electron probe to obtain chemical data about each of the zones on one feldspar crystal. The sites on the crystal sampled, and the results, are shown below.

Feldspar crystal electron probe sites



Sample site	CaO	NaO	K2O
z101	12	67	21
z102	18	73	9
z103	27	71	2
z104	28	67	5
z105	63	29	8
z106	66	31	3
z107	32	65	3
z108	12	70	18
z109	69	29	2
z110	96	2	2
z111	68	26	6
z112	85	11	4

Note : Electron probe results are given as the percent of metallic oxide found in the sample. In this case, the probe only calculated the relative amounts of calcium, potassium and sodium. Any other metal oxides, such as aluminium oxide, were disregarded.

The Feldspar group of minerals differ in composition due to the type of metallic ions in their structure. As calcium, sodium and potassium can fit into the crystal structure there is a continuum of compositions with the end members being Orthoclase (100% potassium), Albite (100% sodium) and Anorthite (100% calcium).

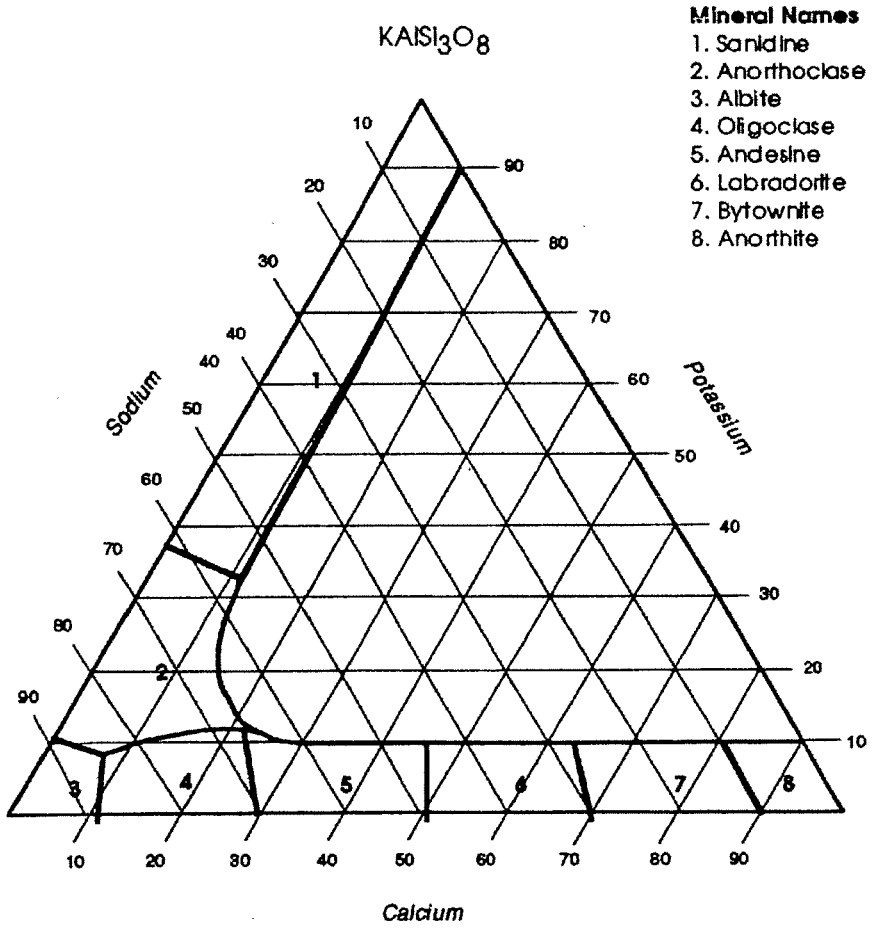
What to Do

1. Using the Feldspar Composition Ternary diagram, plot the composition of each of the sites.

2. As a crystal adds layers to the outside, write the feldspar mineral sequence from the core to the outside of the crystal.

3. What happens to the composition of the solution that this crystal formed in over time and what may have caused the changes?

Feldspar Composition Ternary Diagram



$NaAlSi_3O_8$ $CaAl_2Si_2O_8$

Mineral Phases

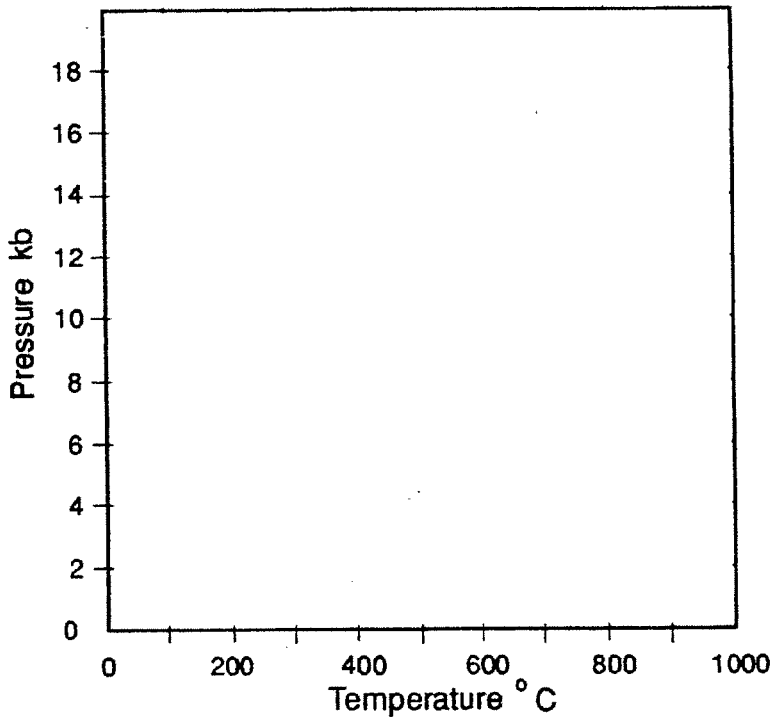
The existence of a chemical in more than one structural form is known as *polymorphism*, with each of the different structures being *allotropes* of the chemical. Diamond and graphite, for example, are naturally occurring allotropes of carbon.
The chemical Al_2SiO_5 is found in nature as three allotropes. These are the minerals Andalusite, Kyanite and Sillimanite. Experiments have shown that the formation of these minerals is somehow dependant on the temperature and pressure of the environment in which they form. In mineralogy, these minerals are referred to as *phases*, and a diagram which represents the relationship between their "environment-of-formation" conditions and mineral phase is call a *Phase Diagram*.

What to do

A number of experiments have been undertaken in which Al_2SiO_5 was placed under different temperature and pressure conditions and the resultant mineral phase recorded. The table of results is below :

Pressure kb	Temperature C	Mineral
7	300	Andalusite
4	50	Andalusite
6	400	Andalusite
3	550	Andalusite
1	100	Andalusite
2	600	Andalusite
6	50	Kyanite
10	400	Kyanite
14	800	Kyanite
8	200	Kyanite
12	300	Kyanite
10	300	Kyanite
16	200	Kyanite
14	700	Kyanite
4	700	Sillimanite
6	500	Sillimanite
8	400	Sillimanite
10	700	Sillimanite
2	800	Sillimanite
12	800	Sillimanite
4	800	Sillimanite
15	900	Sillimanite
5	150	Andalusite
3	300	Andalusite
5	350	Andalusite
7	150	Kyanite
11	550	Kyanite
11	50	Kyanite
13	200	Kyanite
15	450	Kyanite
12	650	Kyanite
9	550	Sillmanite
5	600	Sillmanite
7	650	Sillmanite
7	850	Sillmanite

1. On the graph, plot each of the experiments results, using (a) for Andalusite, (k) Kyanite and (s) Sillimanite.



2. Draw lines on the graph which separate the mineral phases.

3. What mineral phase would you expect to form under the following temperature and pressure environments.

a. 20°C, 101.4 kPa (1 b=101.325 Pa) : _____

b. 500°C, 8 kb: _____

c. 350°C, 350 kb : _____

4. A rock containing the mineral Andalusite was close to a volcanic vent where the temperatures reached 500°C and the mineral phase did not change. What conclusion can you draw from the pressure environment for this location?